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A COANDA INLET/JET FLAP DIFFUSER EJECTOR

Morton Alperin

Flight Dynamics Research Corporation

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BURBANK, CALIFORNIA

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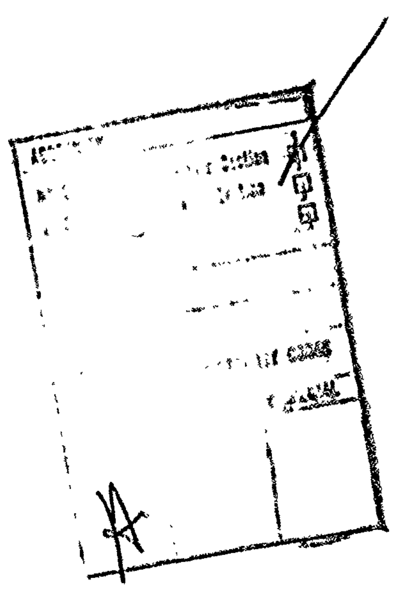

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13. ABSTRACT

The combination of a Coanda inlet and jet flap diffusion, for the achievement of high performance, low volume, thrust augmentation, has been investigated in a two-dimensional experiment.

The Coanda/JFD Ejector has demonstrated a performance superiority, equivalent to 25% in thrust per horsepower, with a volume of approximately 25% of the volume of the highest performance solid diffuser ejector, with conventional inlet.

The use of jet flap diffusion also provides a mechanism for the achievement of large control forces, through the use of variable jet flap angles, or through the application of incremental power to the jet flap.

Vectoring of the total thrust force is achievable through the use of the fluidic effect, which can be utilized to detach the flow from one side of the jet flap, by decreasing the plenum pressure of that side relative to the plenum pressure of the other side.

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FOREWORD

The research reported upon in this document was conducted under Air Force Contract No. F33615-70-C-1656, "Jet Flap Diffuser", Project No. 1366, "Aeromechanics Technology for Military Aerospace Vehicles", Task No. 136617, "Aerodynamic Analysis of Advanced Military V/STOL Aircraft", by Flight Dynamics Research Corp., Burbank, California.

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Work was initiated in June 1970, and completed in August 1972, Mr. R.L. Clark, AFFDL Project Engineer, was the technical monitor for the Air Force.

During various phases of the effort, the author was assisted in the experimental work by Dr. Gary L. Marlotte, and by Mr. G. Gonda-Bonardi.

This technical report has been reviewed and is approved.

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for P.P. Antonatos
Chief, Flight Mechanics Division
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ABSTRACT

The combination of a Coanda inlet and jet flap diffusion for the achievement of high performance, low volume, thrust augmentation, has been investigated in a two-dimensional experiment.

The Coanda/JFD Ejector has demonstrated a performance superiority equivalent to at least 10% in thrust per horsepower, with a volume of approximately 25% of the volume of the solid diffuser ejector with conventional inlet reported in Reference 3.

The use of jet flap diffusion also provides a mechanism for the achievement of large control forces, through the use of variable jet flap angles, or through the application of incremental power to the jet flaps.

Vectoring of the total thrust force is achievable through the use of the fluidic effect, which can be utilized to detach the flow from one side of the jet flap, by decreasing the plenum pressure of that side relative to the plenum pressure of the other side, or by differential operation of the jet flaps.

TABLE OF CONTENTS

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TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF SYMBOLS

A - Minimum Channel Width

a - Primary Jet Exit Area

E - Power

F - Thrust

h - Height in Y-direction

K - Orifice Calibration Constant

m - Mass Flow

p - Pressure

R - Gas Constant

s - Jet Flap Exit Area

T - Absolute Temperature (deg.Rankine)

V - Velocity

x - Coordinate in Thrust Direction

y - Coordinate Normal to Thrust in Plane of Symmetry

z - Coordinate Normal to Thrust and Plane of Symmetry

α - Inlet Area Ratio (A/a)

β - Jet Flap Half Angle

γ - Ratio of Specific Heats (C_p/C_v)

δ - Solid Diffuser Area Ratio (A_2/A)

ϕ - Thrust Augmentation

Ω - Total Thrust x V_j/Total Power

Subscripts

o - Stagnation	1 - Primary	T - Total
p - Fixed Power	2 - Jet Flap	
∞ - Free Stream	RP- Ref. jet related to ϕ_p	

Other symbols and subscripts defined in text as used.

SECTION I

INTRODUCTION

The Coanda/JFD Ejector, is a very compact, high performance device, capable of producing superior thrust augmentation, compared to that of the highest performance solid diffuser, conventional inlet ejectors known.

The inlet, which is comprised of two opposed, two-dimensional nozzles, utilizes the Coanda Effect, to rotate the efflux from these nozzles through ninety degrees, into the thrust plane.

During this rotation, the primary fluid mixes with the ambient air, thereby eliminating the requirement for additional mixing length in the ejector duct.

The Coanda turning produces a velocity distribution at the ejector inlet which assists in delaying separation in the solid diffuser (which is located at the ejector's entrance), thereby making it possible to use short, wide angle solid diffusers.

The jet flap orifice at the downstream end of the solid diffuser also provides a mechanism for delaying separation in the solid diffuser, and when properly designed, provides a mechanism for achieving additional diffusion of the core flow, without solid surfaces.

These effects, in combination, result in an ejector having a volume which is only 25% of the volume, and performance which is at least 10% higher, in terms of thrust per horsepower, than that of the conventional ejector reported in Reference 3.

The jet flap diffusion process also provides a means for achievement of large control forces at constant power, by increase of the jet flap angle, or with power increment applied to the jet flap.

The total thrust force can be directionally controlled, without vanes in the ejector efflux, by means of the "fluidic" effect, which requires only a differential change in the jet flap plenum pressure, or in the jet flap angle.

SECTION II

SUMMARY

The Coanda/JFD Ejector, whose configuration and performance are described in this document, was developed in three phases.

In the first phase, emphasis was placed only upon the inlet, which consisted of two primary nozzles, ejecting fluid in exactly opposite directions. These jet sheets were rotated through ninety degrees by a pair of Coanda surfaces which were slotted to permit the induction of additional air mass. The optimization of these Coanda inlet surfaces, for maximization of the total thrust, was performed without consideration of the effect of diffusion, and is reported upon in Reference 1.

During the second phase, both solid and jet flap diffusers were added to the inlet, to determine the overall performance of the system. In addition, a theory was developed to predict the performance of a jet flap diffuser ejector. Comparison of the measured performance with the theory, indicated large discrepancies, and investigation of the flow field indicated serious degradation of the performance as a result of an interference between the core flow and the jet flap flow. If the jet flap diffuser were to perform as desired, it was shown to be essential that the core flow have a uniform velocity distribution at the jet flap exit slot cross-section. This investigation is reported upon in Reference 2.

Recognition of the necessity for avoiding the presence of low energy regions near the walls, at the jet flap exit cross-section, and the desirability of some solid diffusion, to achieve maximum performance with minimal ejector size, encouraged the initiation of the third phase, which is reported upon in the present document.

Since the critical region at the jet flap slot is strongly influenced by the diffuser boundary layer, and by the slots at the inlet, the third phase investigation was launched to determine whether the overall performance would be seriously affected by closure of the slots and whether solid diffusers could be utilized without adverse effects upon the performance of the jet flap diffuser.

As a result of these investigations, it was learned that closure of the slots, and thereby removal of the region of low energy fluid at the wall, made it possible to utilize short, wide angle solid diffusers, since the

problem of separation in the diffuser was somewhat delayed by the presence of the high energy fluid at the wall, which emanated from the primary jet and remained near the wall as a result of the Coanda turning. In addition, the mixing of the primary and induced flows occurred during the Coanda turning, and the flow at the entrance to the ejector was already completely mixed, thus eliminating the requirement for long mixing lengths in the ejector.

Utilization of these phenomena, produced an ejector of remarkably small size and high performance. The overall geometry and performance are presented in Table I, and compared with other high performance, solid diffuser ejectors.

TABLE I

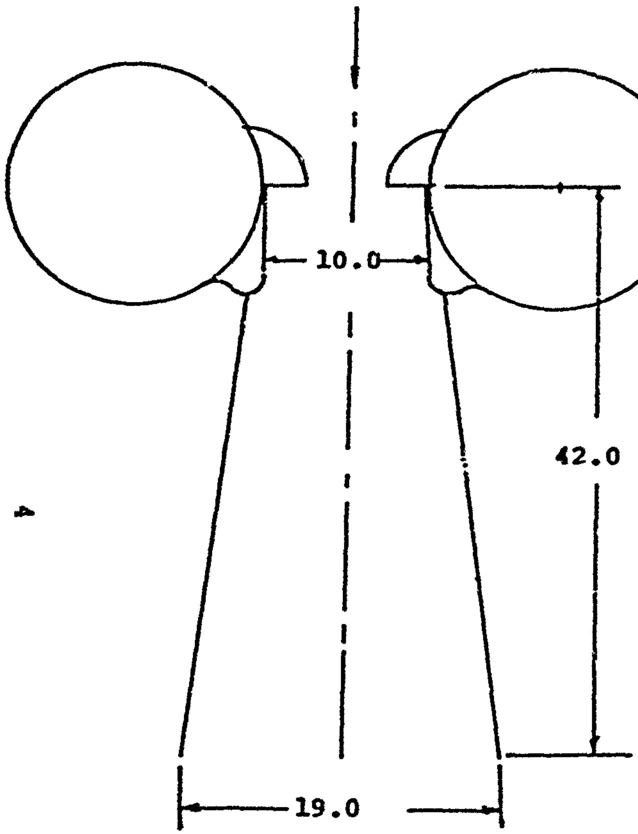
OVERALL EJECTOR GEOMETRIES
AND
PERFORMANCE

EJECTOR	$\frac{A_{max}}{A_{jet}}$ (1)	LENGTH RATIO (2)	$\frac{\text{Thrust} \times V_j}{\text{Power}}$
Coanda/JFD	9	3.5	3.87
Fancher (Ref.3)	38	5.1	3.56
Drummond (Ref.4)	28.5	7.0	2.60
Scott (Ref.5)	43.0	7.0	3.12

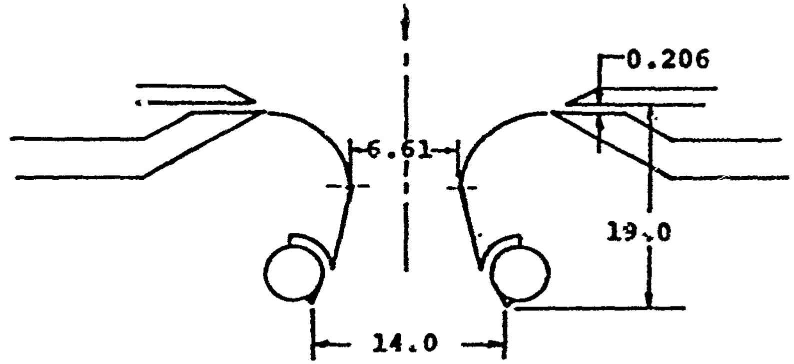
(1) Diffuser exit area/total jet area
(2) Overall length/minimum channel width

The performance comparison presented in the last column of Table I, represents the published data for the solid diffuser devices, but the comparison is weighted in their favor since, as shown in Section VI, the Coanda/JFD Ejector used for comparison, has smaller inlet and diffuser area ratios than those of the solid diffuser ejectors. Despite these limitations, the Coanda/JFD Ejector demonstrated superior performance.

To permit easier visualization of the comparative size of the two types of ejectors, the Coanda/JFD Ejector was scaled up, to the identical power utilization as that of the Fancher Ejector, and schematically compared on Figure 1.



FANCHER EJECTOR (Ref.3)



Coanda/JFD Ejector

Figure 1. JET FLAP and SOLID DIFFUSER EJECTOR
EQUAL TOTAL POWER

The large reduction of ejector volume, attributable to the Coanda inlet and to jet flap diffusion, are readily observable on Figure 1. As a result of the reduced size of the ejector (and therefore reduced skin friction), the overall performance has been greatly improved.

In addition, the use of jet flap diffusion provides a flexibility which is useful in the achievement of large control forces.

A symmetrical change of the flap angle, can produce changes in the total thrust of ten percent, without an accompanying change in power requirement, or with an increment of power, the thrust force can be changed by approximately two to four times that which can be achieved by a solid diffuser ejector (or by an unaugmented jet), without geometrical changes.

As a result of the "fluidic" effect the total thrust force can be vectored, without the requirement for vanes in the ejector or jet efflux, or without gimballing of the thrustor.

SECTION III

APPARATUS

1. EJECTOR RIG

A schematic of the ejector rig is presented on Figure 2, with the major components labeled. The ejector geometry is quasi-two-dimensional, with a basic channel width of two inches, and end plates separated by eighteen inches. Boundary layer control jets are used on each end plate to compensate for the end plate friction.

The major components of the ejector rig are described in detail below.

a. Primary Nozzles

The location of the primary nozzles relative to the ejector channel is illustrated on Figure 3. The slot width a/2, was maintained at 1/16th inch during all tests with the jet flap diffuser

b. Coanda Turning Vanes

The slotted Coanda Vanes used as the basic turning mechanism at the inlet of the ejector are illustrated on Figure 3, and the nomenclature for the slots and other geometrical parameters is also described on this figure.

c. Solid Diffuser

The solid diffuser was formed by sealing Slot No. 4 as illustrated by the dashed line of Figure 3.

d. Jet Flap Diffuser

The Jet Flap Diffuser position and geometry are also illustrated on Figure 3. The jet flap slot width s/2, was varied from 1/16th to 3/16ths of an inch to obtain data at $s/a=1.0$ and 3.0. This was done by variation of the thickness of the spacer between the jet flap plenum and the outer lip. The jets are emitted tangentially to the cylindrical plenums and are rotated by the Coanda Effect until they are prevented from further rotation by the flaps.

e. Boundary Layer Control

Blowing jets were installed in the position shown on Figure 3, to compensate for the end plate friction and

to permit measurement of the total thrust at the rake station, thirty three inches downstream of the jet flap nozzles, without penalty for the end plate skin friction.

To produce a fairly uniform flow at the rake station, it was found necessary to supply air at the boundary layer control orifice having mass flows varying from 5% of the total mass flow, at high values of E, to as much as 15% of the total mass flow at small values of E. This mass flow was not taken into account in the performance of the device since it was not required for the operation of the ejector, and was used merely as a convenient means to correct for the skin friction on the end plates downstream of the diffuser jets (see Fig. 2).

2. AIR SUPPLY

The system air was supplied by a Roots-Connersville Model RAS 60, 50 h.p. compressor, having a volume flow rate of 1500 cfm @ 7 inches of Mercury gauge pressure. A schematic of the air supply system is presented on Figure 4, with its major components identified.

The mass flow to the primary nozzles was controlled by valves in each leg, and measured with standard 3.0 in. orifice plates as illustrated on Figure 4.

The mass flow to the jet flap diffuser nozzles was also controlled by valves in each leg, and measured with standard 2.19 in. orifice plates as illustrated on Figure 4.

The dump line was used to control the system pressure, by means of a valve, as shown on Figure 4. The mass flow through this line was measured with a standard 2.182 in. orifice plate.

3. INSTRUMENTATION

The measurement of pressure across the orifice plates and in the plenum of each nozzle was made with manometers, and the mass flow in each leg of the system was then determined from the orifice pressure drop as described in Section IV.

The total thrust of the ejector was determined from a total head survey at a position 33 inches downstream of the jet flap nozzles, with a 37 tube averaging, total head rake, which was moved across the flow with a parallelogram leadscrew traversing mechanism. The pressure at this station was measured by an inclined oil manometer, connected to the rake through a large settling chamber.

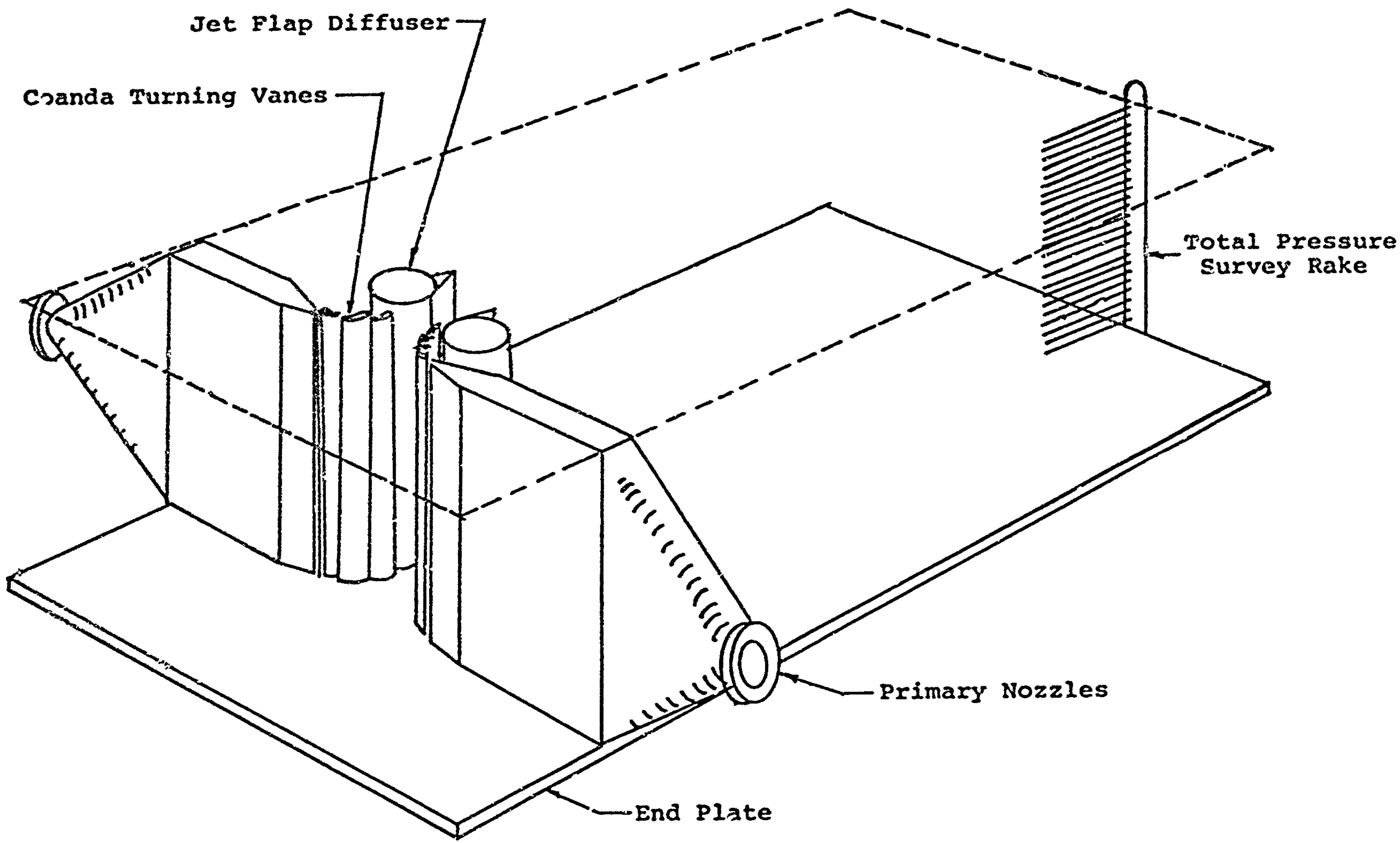
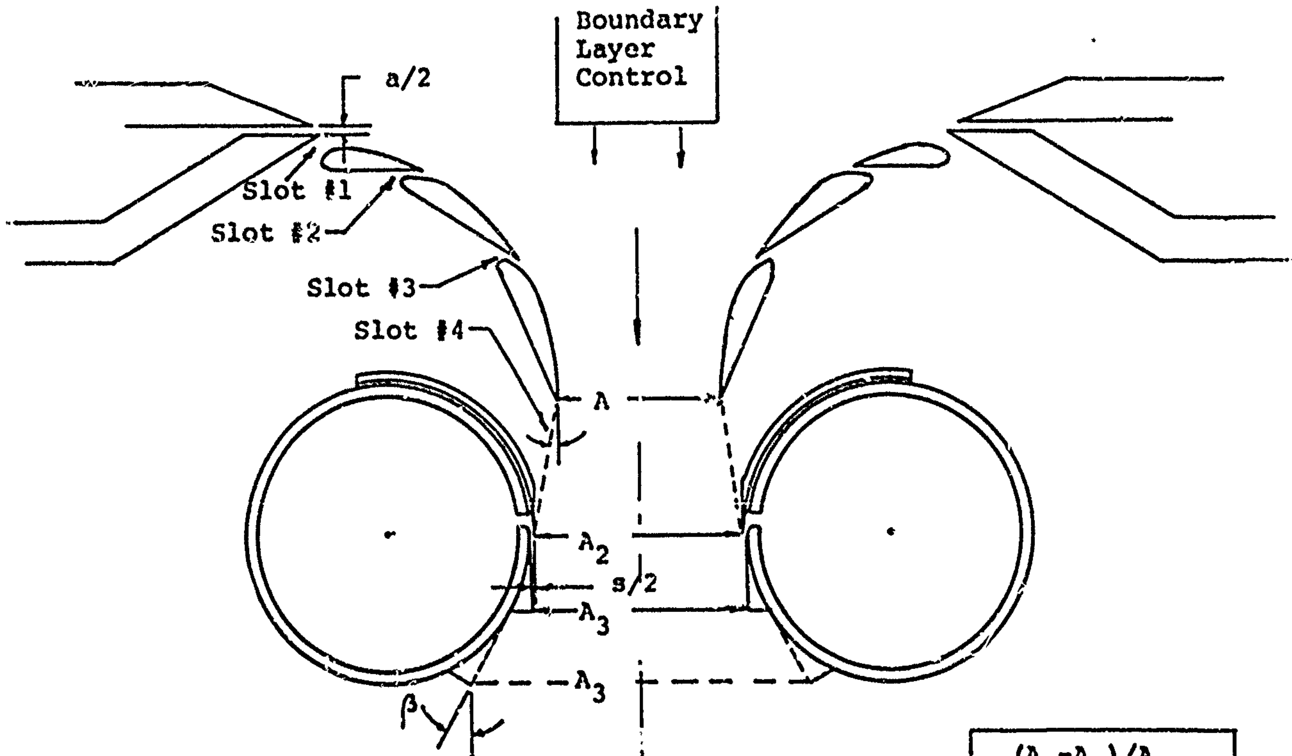


Figure 2. Schematic of Ejector Rig (not to scale)



	$(A_3-A_2)/A$	
β deg.	s/a=1	s/a=3
0	0.0625	0.1875
10	0.2627	0.3877
20	0.5100	0.6350
30	0.7969	0.9219
40	1.1147	1.2397

Figure 3. Schematic of Coanda/JFD Ejector

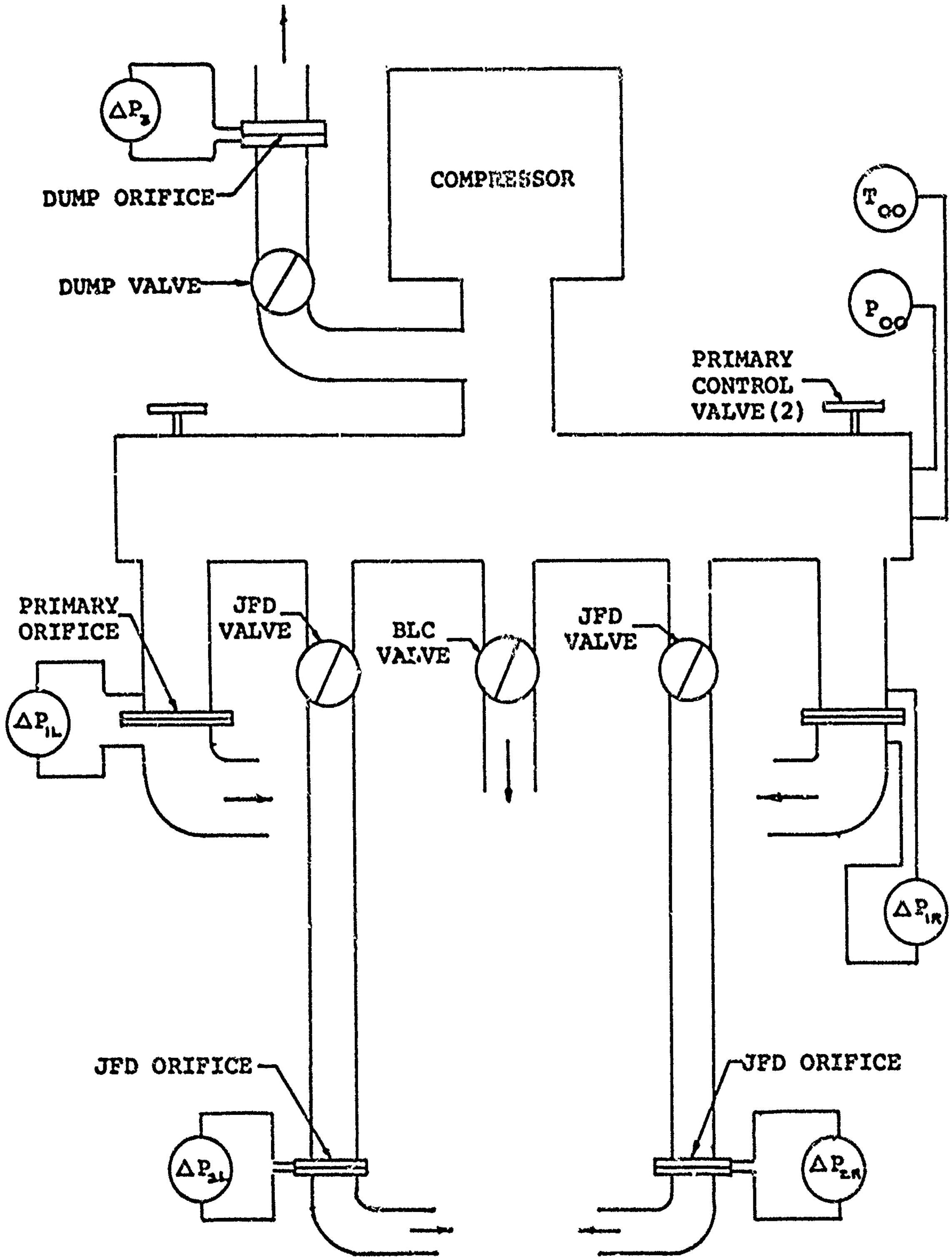


Figure 4. Schematic of Air Supply System

SECTION IV

TEST PROCEDURES

To determine the ejector performance, it is essential to know the performance of the input jets, and the total output of the ejector. Therefore, the mass flow, temperature and pressure at the nozzle entrance and exit, and at the ejector exit were measured. This information was then used to determine the thrust and power of each nozzle, and the total thrust output of the ejector as follows.

The thrust of a nozzle is equal to its mass flow m, multiplied by its average exit velocity,

$$F = \dot{m} \times \overline{V} \tag{1}$$

The mass flow through each nozzle was determined with the aid of the standard orifices located in the duct supplying that nozzle from the relationship,

$$\dot{m} = K\sqrt{\left(\frac{p}{T}\right)(\Delta p)} \tag{2}$$

where
p = static pressure (psia)
T = temperature (deg. R)
K = orifice calibration constant (K_1=.029, K_2=.0175)

The average exit velocity of each nozzle was determined from a calibration of the jet flow, to correct for the viscous effects of the nozzle walls and the spacers used to maintain structural integrity of the slot width. Surveys at the nozzle exit to determine the distribution of stagnation pressure were used to determine the nozzle efficiency η, where,

$$\eta = \left(\frac{1}{A}\right) \frac{\iint [p_o' - p]\, dy\, dz}{(p_o - p)} \tag{3}$$

where
p_o = plenum pressure

p_o' = total pressure measured by survey

A = nozzle exit area

y = coordinate across slot width

z = coordinate along slot length

The nozzle efficiencies determined in this manner, had the following values:

Nozzle	Efficiency
Primary (1/16th in slot)	0.971
Diffuser (1/16th in. slot)	0.965
Diffuser (3.16th in. slot)	0.767

Then knowing the nozzle efficiencies, the average exit velocity $\overline{V}$, could be determined from the pressure drop and stagnation pressure and temperature from the expression,

$$\overline{V} = \sqrt{\left(\frac{2\gamma RT}{\gamma - 1}\right)\left[\left(\eta\frac{(p_o - p)}{p} + 1\right)^{(\gamma-1)/\gamma} - 1\right]} \qquad (4)$$

which derives from compressible flow theory, and the definition of nozzle efficiency.

The nozzle thrust is then determined from Equation 1.

Since the rake survey was made at a large distance downstream from the nozzle exits, the flow at the survey plane was at a sufficiently low Mach No. to permit use of incompressible theory without the introduction of a significant error. Therefore the thrust was determined from the equation

$$F_T = 2\int_{-\infty}^{+\infty}\int_{0}^{h} (p_o' - p)\, dy\, dz \qquad (5)$$

where the integral with respect to y was accomplished by the averaging rake, and the integral with respect to z was performed by numerical integration of the survey data.

These quantities, together with the geometrical parameters, are then used to determine the performance of the ejector in terms of the parameters described in the next section.

SECTION V

TEST RESULTS

Since the C/JFD Ejector utilizes two sources of energy (primary jet and diffuser jet), which in general have different stagnation pressures and temperatures, a description of its performance requires the use of more complex parameters than those utilized for reporting the performance of conventional ejectors.

In addition, to provide a basis for

a. Optimization of the system

b. Comparison of the system with other, more conventional ejector systems, and,

c. Utilization of the reported performance in practical vehicle designs; it appears desirable to use three distinctly different parameters to describe the overall performance of the system. These parameters are briefly defined below and discussed in more detail in Section VI and in Appendix I.

1. PERFORMANCE PARAMETERS

An important goal of any propulsion system is to achieve the maximum thrust available from a given rate of fuel consumption. Other factors such as controllability thrust/weight ratio, size etc., are also to be considered in the selection of a propulsion system but these considerations are beyond the scope of the present report and will be discussed only briefly in Section VI.

For purposes of this document, the optimal system is considered to be that configuration which produces a maximum thrust per unit power input to the system.

Since thrust/power is related to the thermodynamic scale of the device or more precisely, to the stagnation conditions in the driving jets, it is more appropriate to describe its performance in terms of a non-dimensional parameter which is independent of its size and power level.

a. Optimization parameter (Ω)

The ratio of thrust/power can be made non-dimensional by multiplication by a velocity, and in the interest of simplicity, the particular system velocity used was the average primary jet velocity V_{1j}. Further discussion of this choice is presented in Appendix I, but for purposes of discussion of the test relults here, the parameter is defined as

$$\Omega = \frac{\text{Total Thrust X Primary Jet Velocity}}{\text{Total Power Required}} \quad (6)$$

and plots of Ω vs. E, where

$$E = E_2/(E_1 + E_2) \quad (7)$$

is the ratio of diffuser jet power to the total power required by the ejector, are utilized to indicate the effect of the various geometrical or configurational changes as well as the influence of changes in diffuser jet power.

To permit comparison of the C/JFD Ejector with other types of ejectors, whose performance is generally reported in terms of thrust augmentation, the performance of the C/JFD Ejector is also presented in terms of two different thrust augmentation parameters defined as follows.

b.) Fixed mass flow thrust augmentation (ϕ_m)

Comparison of the C/JFD Ejector's thrust output with the thrust output of a free jet which has the same mass flow and power requirement as the ejector jets provides a parameter ϕ_m, which is useful for determination of the C/JFD Ejector performance when the source of power is comprised of a single gas generator having one uniform stagnation pressure, supplying the energized driving fluid to both the primary and the diffuser jets. The nozzle exit area of this free jet is related to the exit areas of the ejector jets s and a, through a relationship involving the stagnation pressures of the various jets and other ejector parameters. These relationships are discussed in Appendix I in some detail, but for purposes of discussion of the test results here, the parameter ϕ_m is defined simply as

$$\phi_m = \frac{\text{Total Ejector Thrust}}{\text{Thrust of free jet with same mass flow and power}} \quad (8)$$

To permit comparison of the C/JFD Ejectors performance with that of a gas generator whose nozzle exit area has a fixed relationship to those of the ejector's jets, a third parameter ϕ_p was developed. This parameter is described briefly below.

c. Fixed nozzle exit area thrust augmentation (ϕ_p)

This parameter ϕ_p, describes the thrust output of a C/JFD Ejector relative to that of a jet whose nozzle exit area is equal to that of the ejector's primary jet (a), and whose total jet power is equal to that of the ejector's jets.

This parameter is defined as

$$\phi_p = \frac{\text{Total Ejector Thrust}}{\text{Thrust of a free jet having } E_{RP} = E_T \text{ and } a_{RP} = a} \tag{9}$$

The test results measured experimentally with various C/JFD Ejector configurations are discussed below and compared with theoretically derived performance, in terms of the three performance parameters described above.

2. PERFORMANCE

Initial testing of the Coanda/JFD Ejector with conventionally designed solid diffusers and a slotted Coanda inlet (developed and optimized for use in a solid diffuser ejector),(Reference 1), demonstrated a serious interference between the diffuser boundary layer and the jet flap diffuser. This interference appeared to be of more serious consequence as a result of the presence of the low energy air induced through the inlet slots. In that configuration, the performance of the device, departed seriously from the theoretical, as indicated by the results of testing reported in Reference 2.

Further testing, with systematic sealing of the inlet slots, and with short, wide angle, diffusers, which appeared to perform satisfactorily, as a result of the interaction with the jet flap, is reported in this document.

Using a basic configuration illustrated schematically on Figure 3, and with various slots sealed, the overall performance was measured and the results in terms of ϕ_m, Ω and ϕ_p and compared to the theory, as described below.

a. Effects of Inlet Slots

As indicated by the dashed line on Figure 3, sealing Slot #4 produced a solid diffuser having an area ratio of 1.12, and a half angle of 7.12 degrees. With this configuration, the performance was measured, over a range of flap angles and with systematic sealing of the slots. Results of these tests at s/a = 3.0 are illustrated on Figures 5,6, and 7.

Figure 5, with β = 30 degrees, illustrates the performance improvement resulting from sealing Slot #4,compared to the performance with all slots open. Sealing this slot, produced performance gains of approximately 15%. Sealing Slots #2 and 3 produced very little additional change, over most of the range of jet flap power ratio.

Sealing of the inlet slots produced noticeable improvement in the steadiness of the flow. This was an indication of the ability of the flow to remain attached to the solid diffuser and to the jet flap.

Increasing the jet flap angle to 40 degrees produced only slight gains of performance, and required increased jet flap power to achieve maximum performance, as illustrated on Figure 6. Further increase of the flap angle caused the flow to become unsteady, and produced no further performance improvement. The performance at $\beta = 50$ degrees, is also illustrated on Figure 6.

For completeness, the performance of this configuration with the flap set at 20 degrees has been measured and the results presented on Figure 7. The maximum values of ϕ_a, ϕ_m and Ω, are smaller than those at =30, 40, and 50 degrees, as expected, but with slots 2, 3, and 4 sealed the flow became extremely steady at $\beta = 20$ degrees.

The influence of the inlet slots with s/a = 1.0, is illustrated on Figure 8. Comparison of performance with all slots open and all slots sealed, indicated gains of 15% to 20% in the value of the performance parameters as a result of sealing the slots.

b. Effect of Solid Diffusion

The effect of further increase of the diffuser half angle was determined by increasing this angle to 12 degrees and testing the configuration with all slots sealed, and with only Slot #1 sealed. The results of these measurements are presented on Figure 9.

As indicated, the performance at small values of E is very close to theoretical, as E increases however, the power of the diffuser jet at first appears ineffective causing a decrease in the value of each parameter. This appears to be due to the fact that there is insufficient diffuser jet power to overcome separation from the flap resulting from its adverse pressure gradient. However, as E is increased above approximately 5%, the performance parameters increase with increasing values of E. At about E = 0.20, the measured performance becomes very close to the theoretical, indicating that the diffuser jet has sufficient power to overcome its adverse pressure gradient and to remain attached to the jet flap, at angles up to 30 degrees.

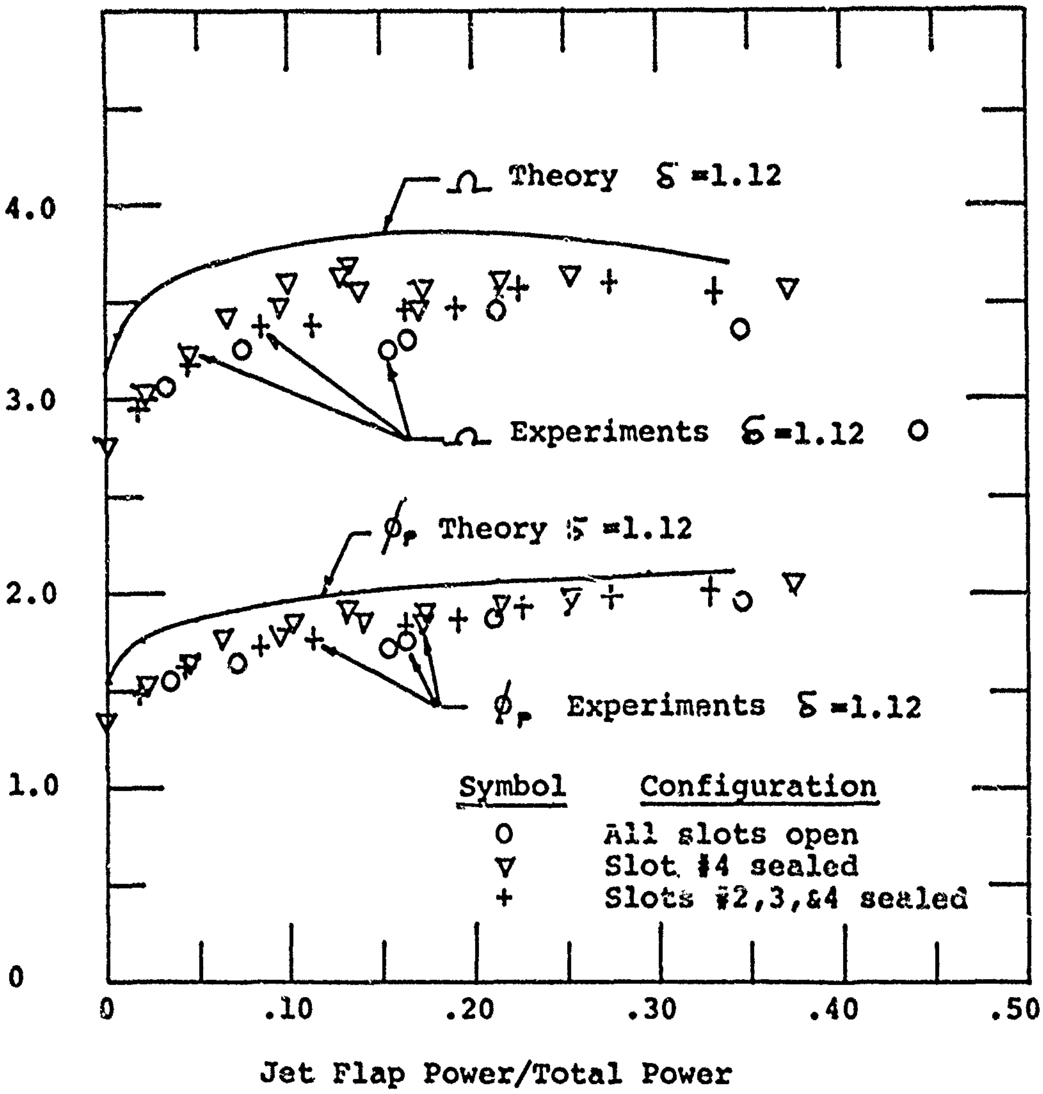


Figure 5. Coanda/JFD Ejector Performance
A/a=16 s/a=3.0 β =30 degrees δ =1.12

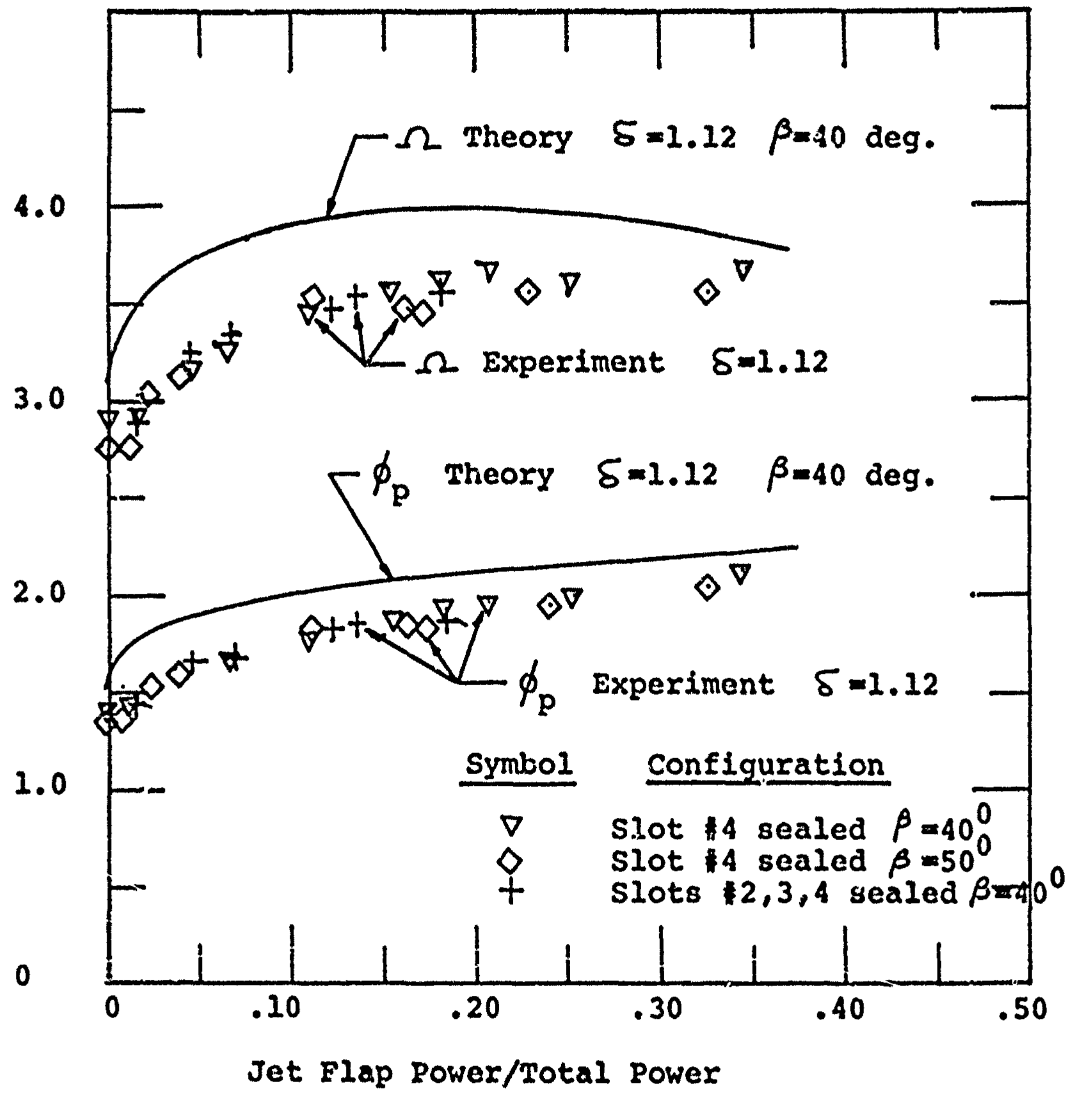


Figure 6. Coanda/JFD Ejector Performance
A/a=16 s/a=3.0 β=40 & 50 deg. δ=1.12

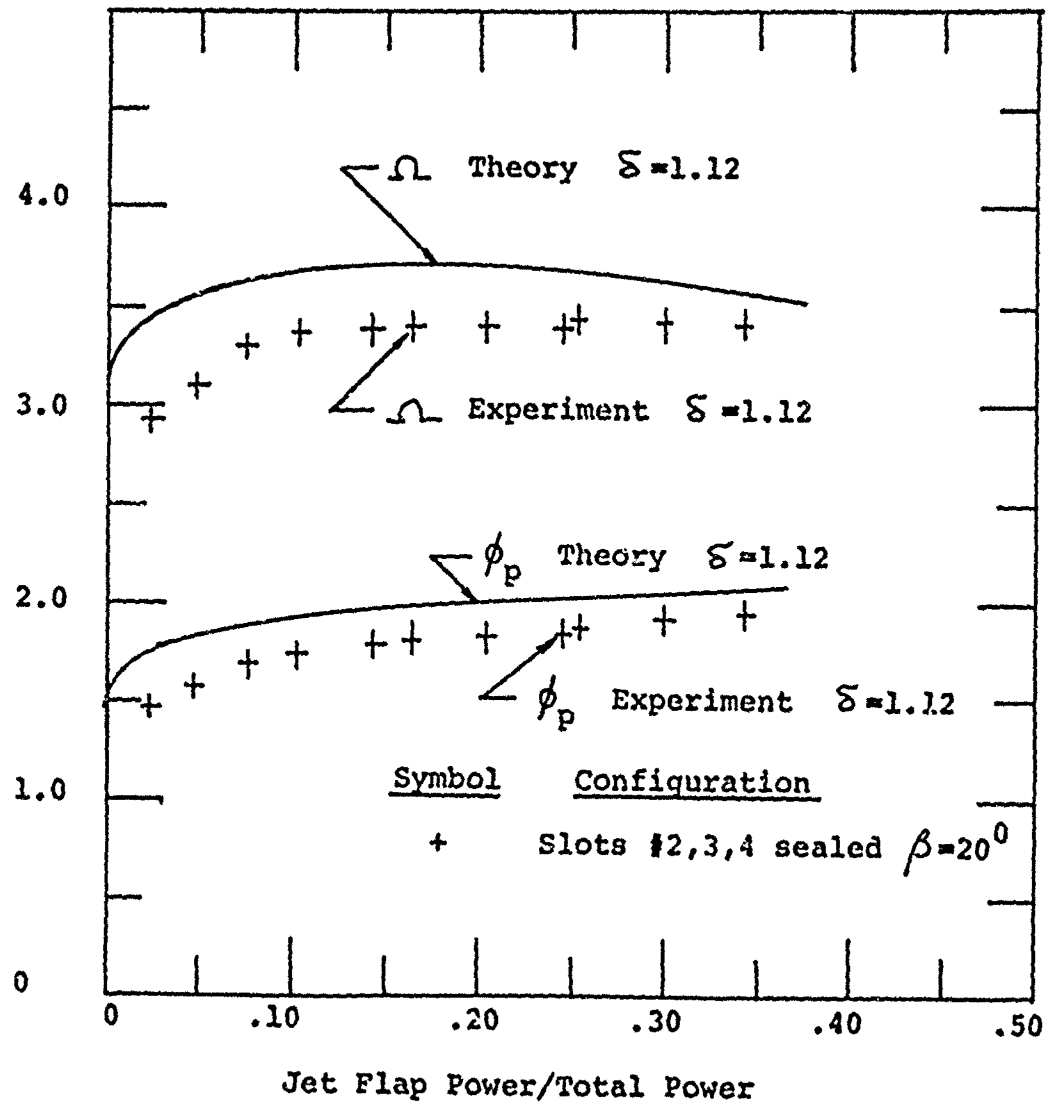


Figure 7. Coanda/JFD Ejector Performance
A/a=16 s/a=3.0 β=20 degrees δ=1.12

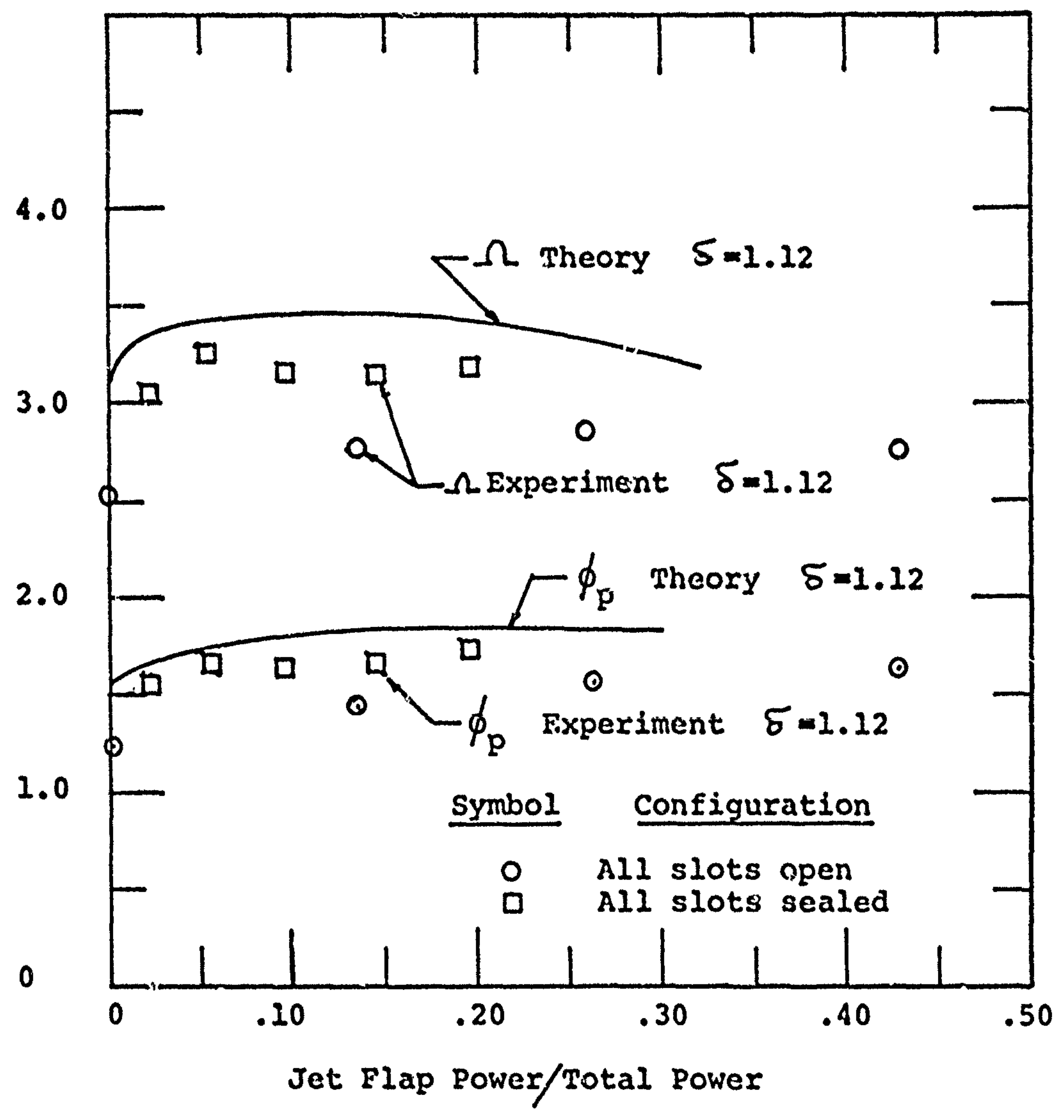


Figure 8. Coanda/JFD Ejector Performance
A/a=16 s/a=1.0 β=20 degrees ς=1.12

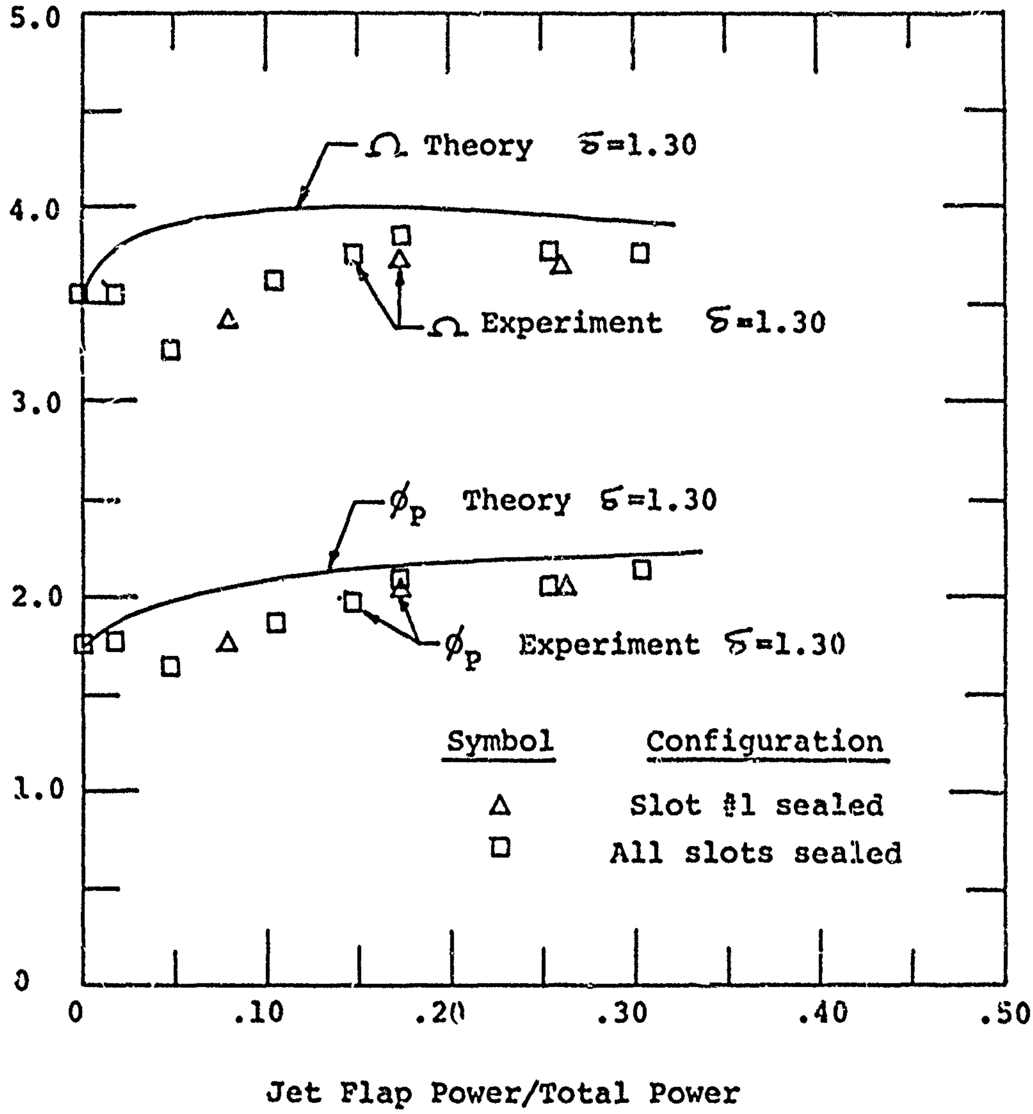


Figure 9. Coanda/JFD Ejector Performance
$A/a=16$, $s/a=3$, $\beta=30$ deg., $\sigma=1.30$

SECTION VI

DISCUSSION

1. PERFORMANCE

The performance of the Coanda/JFD Ejector has been determined experimentally, and the information has been compared with theory, and presented in terms of ϕ_p, ϕ_m and Ω, as functions of the jet flap power ratio in Section V.

Since these parameters are somewhat unconventional for the description of ejector performance, a brief discussion of the significance of these parameters, and their relationship to the thrust augmentation parameter ϕ, used for the description of the performance of solid diffuser ejectors, appears to be appropriate.

High performance solid diffuser ejectors derive approximately 15% to 20% of their thrust as a result of increased mass flow (and therefore increased thrust), through their primary nozzle, due to the presence of the ejector shroud.

The increased mass flow through the primary nozzle requires increased power to drive the primary jet at the same stagnation pressure. This requirement for additional power is seldom discussed in the literature.

Although the Coanda/JFD Ejector requires this additional power only for the jet flap nozzle, it is accounted for in the definition of the parameters Ω, ϕ_p, & ϕ_m Thus these parameters represent a more accurate description of the ejector performance than can be obtained from a knowledge of the conventional parameter ϕ, commonly used to describe the performance of solid diffuser ejectors.

a. Physical Interpretation of Performance Parameters

(1) Thrust Augmentation at fixed area (ϕ_p)

The quantity ϕ_p is the ratio of total ejector thrust to the thrust of a reference free jet having the same nozzle exit area as the ejector's primary jet and the same power requirement as that of all ejector's jets.

The variation of ϕ_p with E (as illustrated on Figures 5-9) is an indication of the relative merits of the application of power to the ejectors diffuser jet

compared to the application of the same percentage of power increment to the free jet without change of its nozzle exit area.

An increase of ϕ_p with increasing E, is indicative of the fact that the power applied to the diffuser jet provides a greater increase of total ejector thrust than would occur if the same percentage of power were applied to the free jet at fixed geometry.

Increases of ϕ_p of as much as 30% are indicated on Figures 5-9 for diffuser jet power of approximately 40% of the total power. As indicated above this implies a superiority in achievement of thrust by the application of power, for the C/JFD Ejector compared to a free jet at fixed nozzle exit area.

(2) Thrust augmentation at fixed mass flow (ϕ_m)

The quantity ϕ_m is the ratio of total ejector thrust to the thrust of a reference free jet having the same mass flow and power requirement as those of the ejector's jets.

Since the reference free jet utilized in evaluating ϕ_m has a nozzle exit area whose relationship to the nozzle exit areas of the ejector's jets changes with E (See Appendix I), it cannot be utilized to evaluate the merits of changes in the diffuser jet power E, in the manner suggested for ϕ_p.

It is very useful however in comparison, at any given value of E, of the ejector's thrust with the thrust of a reference jet having the same mass flow and power requirement as the ejector. It is important however, in making this comparison, to establish the proper relationship between the stagnation pressure of the reference free jet (P_{oRm}) and the stagnation pressures of the ejector's jets (P_{o1} and P_{02}) as indicated in Appendix I.

Variation of ϕ_m with E is very small as indicated by both theory and experiment on Figures 5-9. As discussed above, this fact has very little physical significance since the reference jet has a nozzle exit area a_{Rm} which varies with E.

As indicated on Figure 9, the C/JFD Ejector can provide thrust augmentation of approximately 1.5, compared to a free jet having the same mass flow and power requirement, with a very small area ratio solid

diffuser (δ = 1.3) and a ratio of minimum ejector ejector cross section to driving jet cross section $(A/(a+s))$ of 4.0.

(3) Optimization parameter (Ω)

The quantity Ω is a dimensionless parameter, related to the thrust/power ratio. It is made dimensionless by multiplication of the thrust/power by the average primary jet velocity V_{1j}.

This parameter does not involve a comparison with a reference jet, as do the various thrust augmentation parameters used for the description of performance of conventional ejectors.

Ejectors with more than one driving jet having different stagnation properties cannot be easily compared to a single free jet; however, using Ω, it is possible to evaluate the ejectors performance over a range of variables and to select the optimal conditions as those which produce a maximum value of Ω.

Comparison of the C/JFD Ejector's performance with that of a conventional, single driving jet, ejector can be easily accomplished since the Ω of the conventional ejector is related to the conventional thrust augmentation ϕ as follows, since

$$\phi = \frac{F_T}{F_{Rm}} \qquad (10)$$

for a conventional ejector in which F_{Rm} is the thrust of a reference jet having the same mass flow and power as the ejector, and

$$\Omega = \frac{(F_T/F_1)\ V_{1j}}{E_T/F_1} = 2\ (F_T/F_1)\ (1 - E) \qquad (11)$$

for a C/JFD Ejector.

Therefore, for a conventional ejector in which $E = 0$, and $F_1 = F_{Rm}$

$$\Omega = 2\ \phi \quad \text{(Conventional ejector)} \qquad (12)$$

It is also interesting to note that for a free jet

$$\Omega = \frac{F\ V_j}{E_T} = 2.0 \text{ (free jet)} \qquad (13)$$

In view of the simplicity of the parameter Ω for purposes of

a) Optimization

b) Comparison with other ejector systems

c) Design applications

it appears to be a universally applicable parameter which can be easily evaluated for any geometrical or thermodynamic configuration, and is independent of the choice of reference jet properties.

On the basis of Ω, it can be observed on Figure 9, that the C/JFD Ejector has achieved a thrust of almost twice that achievable by a free jet with the same power, despite the fact that in that particular configuration it has a small diffuser area ratio (δ = 1.3) and a ratio of ejector minimum cross section/total nozzle exit area, of only 4.0.

2. COMPARISON OF C/JFD EJECTOR WITH CONVENTIONAL EJECTORS

A comparison of the performance of the C/JFD Ejector with that of several conventional, high performance ejectors on the basis of Ω is presented in Table II.

TABLE II

COMPARISON OF EJECTOR CHARACTERISTICS

Ejector	Inlet Area Ratio	Diffuser Area Ratio	Length Ratio (2)	Ω
C/JFD	4.0 (1)	1.3	3.0	3.94 (3)
Fancher (Ref.3)	19.0	1.9	5.1	3.56
Drummond (Ref.4)	19.0	1.5	7.0	2.60
Scott (Ref.5)	21.5	2.0	7.0	3.12

(1) Minimum Channel area/total jet exit areas

(2) Overall length/minimum channel width

(3) E = 0.161, β = 30 deg. (Run 343)

Using the theory of Ref. 2 which produces good agreement with experiment, as illustrated on Figures 5-9, the value of Ω increases by approximately 12% for an increase in the C/JFD solid diffuser area ratio (δ) from 1.3(as in the above table) to δ = 1.9. This would indicate that at δ = 1.9, the C/JFD Ejector would produce Ω = 4.41, at the same inlet area ratio ($A/(a + s)$ = 4.0). This represents a considerable advantage in performance over the best solid diffuser ejector reported to date with a geometrical advantage requiring only approximately 25% of the volume of the solid diffuser ejector.

3. C/JFD EJECTOR AS A CONTROL DEVICE

The jet flap diffuser provides a mechanism which can be utilized for control of the magnitude and direction of the thrust ejector.

a. Thrust Vectoring

Although detailed measurements were not made during the experiments reported in this document, it was observed, that the entire efflux from the ejector could be easily controlled directionally, by simple opening or closing of the valve in either supply leg to the diffuser jets. In addition, thrust vectoring could also be achieved by differential operation of the small flaps used to control the diffuser jet angle β .

b. Thrust Magnitude Control

The magnitude of the thrust vector achievable by a jet flap diffuser ejector is controllable by two methods.

(1) Power Increment Response

The application of additional power to the diffuser jet causes large changes in Ω. As illustrated on Figure 9, Ω increases with increasing values of E, up to E = 0.18. Thus it is apparent that the application of additional power in this region will produce thrust increases larger than those achievable from a free jet or from a conventional ejector whose Ω or ϕ is independent of power level.

(2) Flap Angle Response

Control of the magnitude of the thrust vector can be achieved by symmetrical changes in the jet flap angle For example, comparison of Figures 5 and 7 illustrate an increase in thrust of approximately 20% as a result of a change of 10 degrees in β , with fixed power.

SECTION VII

CONCLUSIONS

The Coanda/Jet Flap Diffuser Ejector, occupying approximately twenty five percent of the volume of the solid diffuser ejector reported in Reference 3, has demonstrated experimentally that it can deliver ten percent more thrust per horsepower than the solid diffuser ejector, despite the fact that the C/JFD Ejector had smaller inlet and diffuser area ratios than those of the solid diffuser device to which it was compared.

Extrapolation of the performance, to a configuration having comparable diffuser area ratios, but with the same disadvantage to the C/JFD Ejector in terms of the inlet area ratio, indicated a twenty five percent advantage in thrust per horsepower for the C/JFD Ejector over the solid diffuser ejector.

The use of jet flap diffusion also demonstrated a unique capability for production of large control forces and for vectoring of those control forces by means of symmetrical or asymmetrical movement of the jet flaps.

The C/JFD Ejector also demonstrated the capability to produce control forces in response to incremental power which was considerably in excess of those available from conventional ejectors or from free jets.

APPENDIX I

DETERMINATION OF EJECTOR PERFORMANCE

Appendix I

Determination of Ejector Performance

1. Experimental Measurements

The determination of the values of the performance parameters Λ, ϕ_p, and ϕ_m from the experimental data is complicated by the fact that the ejector is two dimensional and each jet (primary and diffuser) is comprised of two elements, one on each side of the plane of symmetry.

As a result of the lack of exact symmetry due to manufacturing tolerances, it was necessary to adjust the thermodynamic properties in a manner which created slightly different values of the stagnation pressure and mass flow between the right and left side of each set of nozzles to produce a symmetrical efflux.

These differences created some complexity in determination of the velocities V_{1i} and V_{2i} for use in evaluation of each of the performance parameters. The technique used is described below in detail.

The measurements made during the experiment included the following, for each test set up. (See Fig. 4)

a. Stagnation temperature (T_o)

b. Atmospheric pressure and temperature (p_∞ , T_∞)

c. Orifice pressure drops (ΔP_{1L}, ΔP_{1R}, ΔP_{2L}, ΔP_{2R})

d. Nozzle plenum pressures (P_{o1L}, P_{o1R}, P_{o2L}, P_{o2R})

e. Static pressure at diffuser jet ($P_{ch.}$)

f. Total thrust (F_T)

2. NOZZLE PERFORMANCE

The mass flow through each nozzle was then calculated from its orifice pressure drop, using the calibration constants as described in Section IV, Eq. 2.

The average jet velocities V_{1jL}, V_{1jR}, V_{2jL}, V_{2jR} were then determined for each nozzle, using the measured stagnation temperature and pressure and the appropriate nozzle efficiency as described in Section IV, Eq. 4.

Using these values of mass flow and velocity for each of the four nozzles, the values of the power required to drive each nozzle was determined as follows.

Since the primary nozzles exhausted into a virtually undisturbed region, the pressure at these nozzle exits was taken to be P . Therefore

$$E_{1L} = 1/2\ \dot{m}_{1L}\ V_{1L}^2 \tag{14}$$

$$E_{1R} = 1/2\ \dot{m}_{1R}\ V_{1R}^2 \tag{15}$$

and

$$E_1 = E_{1L} + E_{1R} \tag{16}$$

the thrust of each primary nozzle is;

$$F_{1L} = \dot{m}_{1L}\ V_{1L} \tag{17}$$

$$F_{1R} = \dot{m}_{1R}\ V_{1R} \tag{18}$$

and

$$F_1 = F_{1L} + F_{1R} \tag{19}$$

The average primary jet velocity was then determined from the relationship

$$V_{1j} = \sqrt{\frac{2\ (E_{1L} + E_{1R})}{m_{1L} + m_{1R}}} \tag{20}$$

and the primary jet mass flow is,

$$m_1 = m_{1L} + m_{1R} \tag{21}$$

The power required to drive the diffuser jets which exhaust into a region having a pressure somewhat below ambient is,

$$E_{2L} = 1/2\ \dot{m}_{2L}\ V_{2L\infty}^{2} \tag{22}$$

$$E_{2R} = 1/2\ \dot{m}_{2R}\ V_{2R\infty}^{2} \tag{23}$$

and

$$E_2 = E_{2L} + E_{2R} \tag{24}$$

where

$$\frac{V_{2L(R)\infty}}{V_{2L(R)}} = \sqrt{\frac{1 - \left(p_\infty / p_{o2L(R)}\right)^{(\gamma-1)/\gamma}}{1 - \left(p_{d1} / p_{o2L(R)}\right)^{(\gamma-1)/\gamma}}} \tag{25}$$

and the thrust of each diffuser jet is

$$F_{2L} = \dot{m}_{2L}\ V_{2jL} \tag{26}$$

$$F_{2R} = \dot{m}_{2R}\ V_{2jR} \tag{27}$$

and

$$F_2 = F_{2L} + F_{2R} \tag{28}$$

The average diffuser jet velocity was then determined from the relationship;

$$V_{2j} = \sqrt{\frac{2\ (E_{2L} + E_{2R})}{m_{2L} + m_{2R}}} \tag{29}$$

and the diffuser jet mass flow is

$$m_2 = m_{2L} + m_{2R} \tag{30}$$

3. PERFORMANCE PARAMETERS

Using these average values for E_1, E_2, F_1, F_2 and m_1 and m_2, the performance parameters were determined as follows:

a. Optimization parameter (Ω)

The value of Ω is determined from its definition (Eq. 6) using the total thrust which was measured by a wake survey as described in Section IV, the primary jet exit velocity V_{1j} and the total power E_T, where

$$E_T = E_1 + E_2 \qquad (31)$$

thus

$$\Omega = \frac{F_T \times V_{1j}}{E_T} \qquad (32)$$

b. Fixed mass flow thrust augmentation(ϕ_m)

To evaluate this parameter it is necessary to determine the thrust (F_{Rm}) of a free jet having

$$\dot{m}_{Rm} = \dot{m}_1 + \dot{m}_2 \qquad (33)$$

and

$$E_{Rm} = E_1 + E_2 \qquad (34)$$

Since the reference jet is a free jet (expanding from its stagnation pressure P_{oRm} to the ambient pressure P_∞, its effective velocity is

$$V_{Rm} = \sqrt{\frac{2E_{Rm}}{\dot{m}_{Rm}}} \qquad (35)$$

and therefore its thrust is

$$F_{Rm} = \sqrt{2E_{Rm} \cdot \dot{m}_{Rm}} = \sqrt{2(E_1 + E_2)\ (\dot{m}_1 + \dot{m}_2)} \qquad (36)$$

and the augmentation parameter ϕ_m is

$$\phi_m = \frac{F_T}{F_{Rm}} \qquad (37)$$

The value of ϕ_m obtained in the avove manner provides information which relates the ejector's thrust to the thrust of a free jet gas generator having a mass flow and total jet power equal to those of the ejector's jets. However, in the general case, in which $P_{o1} \neq P_{o2}$, the stagnation pressure and the jet area of the reference jet both vary in relation to the ejector jets as the diffuser jet power ratio E changes. These relationships can be expressed as follows:

$$\frac{p_{oRm}}{p_\infty} = \left\{1 - \left(\frac{1-m}{1-E}\right)\left[1 - \left(\frac{p_\infty}{p_{o1}}\right)^{(\gamma-1)/\gamma}\right]\right\}^{\frac{-\gamma}{\gamma-1}} \qquad (38)$$

and

$$\frac{a_{RM}}{a} = \sqrt{\frac{1-E}{(1-m)^3}} \qquad (39)$$

where $m = m_2/(m_1 + m_2)$ in the above equations.

These relationships imply that while ϕ_m is an excellent indicator of thrust augmentation available from a particular ejector geometry at any given operating condition (fixed E and m), it is not useful as an optimization parameters since the reference jet is in effect a "rubber" engine, in both the geometric and thermodynamic sense. If however, the ejectors jets are all supplied from a common source, the parameter ϕ_m can then be used to relate the ejectors thrust to that of the gas generator having a fixed stagnation pressure (independent of E and m) and is "rubber" only in the geometric sense.

In this case since

$$P_{o1} = P_{o2} = P_{oRm} \qquad (40)$$

the ejectors nozzles are designed with areas related to the nozzle areas of the reference jet as follows:

$$a_{Rm}/a = (m_{Rm}/m_1)\ (\rho_1 V_{1j}/\rho_{Rm} V_{Rm}) \qquad (41)$$

and within the approximation that all densities are equal this can be simplified to

$$a_{Rm}/a = m_{Rm}/m_1 \qquad (42)$$

and since s/a is chosen on the basis of other ejector and vehicle design considerations, the distribution of the mass flow from the gas generator between the primary and the diffuser jet is easily determined, since

$$a_{Rm} = a + s \tag{43}$$

for this case in which $P_{o1} = P_{o2} = P_{oRm}$

c. Fixed nozzle area thrust augmentation ($\emptyset_p$)

Since in the general case in which $P_{o1} \neq P_{o2}$, the relationship among the nozzle exit areas of the ejector and the reference jet is complex and varies with the parameters $E(= E_2/E_1 + E_2)$ and $m(= m_2/m_1 + m_2)$, a third parameter $\emptyset_p$, having a fixed reference jet exit area (a_{RP}) and reference jet power (E_{RP}) equal to that of all ejector jets, was used to describe the relative performance of the ejector. In this case the reference jet is related to the ejector jets as follows

$$a_{RP} = a \tag{44}$$

$$E_{RP} = E_1 + E_2 \tag{45}$$

From these relationships, the thrust of the ejector F_T, can be expressed in terms of the thrust of the reference jet as

$$\emptyset_p = \frac{F_T}{F_{RP}} = \frac{F_T/F_1}{(1 + E_2/E_1)^{2/3}} = \emptyset\ (1-E)^{2/3} \tag{46}$$

where $$\emptyset = F_T/F_1 \tag{47}$$

The parameter $\emptyset_p$ relates the ejector thrust to the thrust of a fixed nozzle gas generator, and therefore is more convenient than $\emptyset_m$ for design purposes. The reference jet utilized to define this parameter ($\emptyset_p$) must have a single stagnation pressure different from either of the ejectors jets, as in the case of $\emptyset_m$, or as would be required for any performance parameter using a single reference jet for comparative purposes. In this case, the stagnation pressure of the reference jet is related to the stagnation pressure of the ejectors primary jet as follows.

$$\frac{P_{o1}}{P_{\infty}} = \left\{1 - (1-E)^{2/3}\left[1 - (p_{\infty}/p_{oRP})^{(\gamma - 1)/\gamma}\right]\right\}^{-\frac{\gamma}{\gamma-1}} \tag{48}$$

Thus the relationship among the stagnation pressure of the reference jet and the ejector jets is dependent upon the power supplied to the diffuser jet, as in the case of the reference jet used to define ϕ_{η}, but this reference jet is "rubber' only in the thermodynamic sense since its geometry is fixed by the relationship of Eq. 1-32.

APPENDIX II

TEST DATA

COANDA/JFD EJECTOR

TEST DATA

s/a=3.0, σ=1.12

ALL SLOTS OPEN

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_o - P_\infty$ R L " (2.95)	$P_{o2} - P_\infty$ R L " (2.95)	ΔP_1 R L " (H_2O)	ΔP_2 R L " (H_2O)
206	30	106	29.55	3.20	25.25 30.45	4.80 4.05	4.00 3.80	15.30 15.55
207	30	108	29.55	4.80	21.40 25.85	6.30 5.00	3.40 3.30	19.60 20.35
208	30	115	29.55	2.20	30.25 34.70	2.35 1.55	4.70 4.40	8.15 5.65
209	30	93	29.45	6.65	21.50 25.00	9.55 8.20	3.45 3.30	28.70 32.10
210	30	106	29.45	3.20	24.15 28.10	5.65 4.60	3.80 3.55	17.60 17.50
211	30	112	29.45	2.00	26.35 30.60	3.20 2.70	4.15 3.90	10.70 10.20
212	30	118	29.50	2.05	26.90 27.70	3.25 2.70	4.30 3.45	10.90 10.45

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\sigma = 1.12$

SLOT #4 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R / L	$P_{o2} - P_\infty$ " (2.95) R / L	ΔP_1 " (H_2O) R / L	ΔP_2 " (H_2O) R / L
213	30	112	29.50	3.70	26.95 27.85	3.25 2.70	4.25 3.45	10.85 10.50
214	30	120	29.50	5.20	31.45 32.40	6.10 4.95	4.95 4.00	19.05 18.70
216	30	107	29.50	7.55	28.40 29.40	6.40 5.10	4.50 3.65	20.55 20.90
217	30	102	29.27	10.00	32.00 32.95	6.15 4.60	4.90 3.95	18.05 18.25
218	30	104	29.27	7.10	26.70 27.55	5.15 3.85	4.15 3.40	15.15 15.20
219	30	105	29.30	5.30	29.40 30.25	4.55 3.40	4.50 3.70	13.90 13.60
220	30	106	29.30	3.80	28.55 29.60	3.20 2.55	4.40 3.55	10.15 9.95
221	30	108	29.30	4.25	28.55 29.50	2.85 2.80	4.40 3.55	9.25 11.25
222	30	110	29.35	5.30	29.25 30.25	3.85 3.80	4.60 3.75	12.20 15.15

COANDA/JFD EJECTOR

TEST DATA

s/a= 3.0, σ = 1.12

SLOT #4 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R L	$P_{o2} - P_\infty$ " (2.95) R L	ΔP_1 " (H_2O) R L	ΔP_2 " (H_2O) R L
223	30	108	29.45	6.20	31.55 32.55	5.50 5.45	4.90 3.95	16.80 21.20
224	30	110	29.45	7.00	29.40 30.35	6.45 5.90	4.55 3.70	19.05 22.65
225	30	110	29.45	7.50	27.75 28.65	7.20 6.80	4.35 3.55	20.80 25.55
226	30	111	29.47	7.80	26.35 27.15	8.00 7.20	4.10 3.35	22.55 26.80
227	30	107	29.47	8.50	22.45 23.20	10.70 9.15	3.60 2.95	28.15 32.10
228	30	116	29.48	3.60	29.95 30.95	2.00 2.45	4.65 3.75	6.55 9.70
229	30	127	29.50	3.10	36.90 38.10	---- ----	5.65 4.50	---- ----
230	30	107	29.50	3.30	34.55 35.85	1.55 1.65	5.30 4.25	5.15 6.60

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\delta = 1.12$

SLOT #4 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R/L	$P_{o2} - P_\infty$ " (2.95) R/L	ΔP_1 " (H_2O) R/L	ΔP_2 " (H_2O) R/L
239	50	111	29.42	2.30	32.30 34.45	0.80 1.05	4.95 4.00	2.60 4.05
240	50	106	29.40	2.90	34.70 35.80	---- ----	5.30 4.15	---- ----
241	50	114	29.40	3.40	31.15 32.30	2.30 2.20	4.80 3.90	7.05 8.10
242	50	117	29.40	3.50	30.75 31.80	2.15 2.30	4.80 3.85	7.10 8.80
243	50	120	29.40	4.40	31.25 32.40	3.00 3.30	4.90 3.95	9.90 12.95
244	50	124	29.40	6.15	32.80 34.05	4.05 5.35	5.05 4.15	14.25 20.60
245	50	116	29.40	6.80	30.05 31.25	5.30 6.25	4.75 3.80	22.80 23.65
246	50	108	29.45	6.70	30.30 31.45	5.70 6.30	4.70 3.80	16.80 23.75
305	50	106	29.52	8.60	27.25 28.20	7.65 8.35	4.25 3.45	21.75 24.70
306	50	110	29.52	9.40	24.25 25.05	8.40 9.50	3.85 3.10	24.45 33.35

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\sigma = 1.12$

SLOT #4 SEALED

RUN	β	T_o ^oF	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_\alpha - P_\infty$ " (2.95) R / L	$P_{o2} - P_\infty$ " (2.95) R / L	ΔP_1 " (H_2O) R / L	ΔP_2 " (H_2O) R / L
247	40	112	29.58	8.00	29.55 30.60	5.95 6.55	4.60 3.60	18.50 25.25
248	40	120	29.58	6.30	27.00 28.05	4.95 5.15	4.25 3.45	15.60 19.85
249	40	124	29.58	5.50	29.45 30.60	4.05 4.35	4.55 3.70	13.00 16.85
250	40	132	29.58	5.20	33.25 34.40	3.05 3.35	5.05 4.15	9.90 13.15
251	40	130	29.58	3.40	27.65 28.60	1.95 2.40	4.30 3.50	6.45 9.35
252	40	132	29.58	2.60	32.40 33.55	0.95 1.30	4.90 4.00	3.35 5.30
253	40	137	29.58	2.70	33.20 34.80	---- ----	5.05 4.00	---- ----
301	40	106	29.45	9.65	23.55 24.45	8.90 9.40	3.70 3.00	25.30 33.55
302	40	104	29.52	8.10	28.60 29.55	6.90 6.90	4.35 [illegible].55	20.15 25.65
303	40	107	29.52	8.90	27.50 28.55	7.50 8.25	4.20 3.45	21.85 29.90

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\sigma = 1.12$

SLOTS #2,3,4 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R / L	$P_{o2} - P_\infty$ " (2.95) R / L	ΔP_1 " (H_2O) R / L	ΔP_2 " (H_2O) R / L
254	40	119	29.58	2.25	30.70 31.75	1.00 1.35	4.75 3.85	3.50 5.50
255	40	124	29.58	3.45	27.80 31.90	2.00 2.45	4.75 3.85	6.60 9.55
256	40	127	29.58	4.35	31.35 32.35	3.05 3.35	4.80 3.90	9.85 12.95
257	40	125	29.59	5.50	27.50 28.30	4.00 4.55	4.30 3.50	12.55 17.55
258	40	127	29.58	6.75	31.45 32.60	5.00 5.60	4.85 4.00	15.60 21.90
259	40	127	29.58	7.10	28.50 29.75	5.95 6.45	4.50 3.65	18.10 25.00

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\delta = 1.12$

SLOTS #2,3,4 SEALED

RUN	β	T_o ^oF	P_∞ " Hg	$P_o - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R L	$P_{o2} - P_\infty$ " (2.95) R L	ΔP_1 " (H_2O) R L	ΔP_2 " (H_2O) R L
260	30	100	29.50	7.50	29.30 30.40	6.15 6.90	4.50 3.65	18.65 25.95
261	30	107	29.50	6.50	27.15 28.05	5.20 5.40	4.25 3.40	15.75 20.55
262	30	112	29.50	5.95	29.85 30.95	4.10 4.50	4.60 3.75	13.00 17.85
263	30	116	29.50	4.35	28.05 29.05	3.05 3.35	4.35 3.55	9.85 13.65
264	30	120	29.50	3.95	31.95 32.95	2.05 2.45	4.85 4.00	6.90 10.10
265	30	122	29.50	2.40	27.50 28.60	1.00 1.25	4.25 3.55	3.45 5.00
266	30	120	29.50	8.00	28.30 29.25	7.05 7.65	4.40 3.55	20.65 28.35
268	30	120	29.50	8.25	25.85 26.70	8.00 8.35	4.05 3.35	22.55 30.00
269	30	118	29.50	8.45	23.90 24.65	9.00 9.35	3.80 3.15	24.55 32.55

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$ $\delta = 1.12$

SLOTS #2,3,4 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ R/L " (2.95)	$P_{o2} - P_\infty$ R/L " (2.95)	ΔP_1 R/L " (H_2O)	ΔP_2 R/L " (H_2O)
270	20	105	29.50	6.10	24.20 25.10	9.80 10.10	3.75 3.10	24.45 32.45
271	20	110	29.50	6.60	25.80 26.75	9.10 9.40	4.00 3.30	23.15 30.80
272	20	115	29.50	6.45	28.00 29.00	8.05 8.40	4.35 3.55	21.50 28.45
273	20	118	29.50	6.30	26.90 27.85	8.05 8.35	4.20 3.45	21.10 27.90
274	20	119	29.50	6.25	29.00 30.05	7.10 7.45	4.55 3.65	19.00 25.65
275	20	124	29.50	6.10	31.05 32.15	6.05 6.75	4.80 3.90	16.85 23.80
276	20	123	29.50	5.30	28.30 29.40	5.05 5.35	4.40 3.60	14.30 19.45
277	20	124	29.50	5.05	30.60 31.70	4.05 4.40	4.70 3.85	12.10 16.65
278	20	123	29.50	4.35	28.60 29.55	3.00 3.30	4.45 3.60	9.30 12.85

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\sigma = 1.12$

SLOTS #2,3,4 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_\alpha - P_\infty$ " (2.95) R / L	$P_{o2} - P_\infty$ " (2.95) R / L	ΔP_1 " (H_2O) R / L	ΔP_2 " (H_2O) R / L
279	20	120	29.50	3.55	27.90 28.95	1.95 2.45	4.35 3.55	6.45 9.70
280	20	118	29.50	2.65	26.65 27.70	1.05 1.45	4.15 3.40	3.70 6.10

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\sigma = 1.30$

SLOT #1 SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R / L	$P_{o2} - P_\infty$ " (2.95) R / L	ΔP_1 " (H_2O) R / L	ΔP_2 " (H_2O) R / L
329	30	109	29.40	3.80	29.00 30.60	3.15 2.85	4.05 3.05	10.55 13.40
330	30	110	29.40	5.30	27.05 28.50	5.10 5.65	3.85 2.95	16.45 25.25
331	30	110	29.40	[illegible].45	26.25 27.65	7.45 7.30	3.75 2.85	23.05 32.20

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0$, $\sigma = 1.30$

ALL SLOTS SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ R/L " (2.95)	$P_{o2} - P_\infty$ R/L " (2.95)	ΔP_1 R/L " (H_2O)	ΔP_2 R/L " (H_2O)
335	30	115	29.38	4.50	27.30 28.55	---- ----	4.15 3.30	---- ----
338	30	111	29.38	9.90	30.30 31.50	5.10 5.70	4.55 3.65	16.95 25.50
339	30	108	29.38	4.50	27.30 28.55	1.05 1.15	4.15 3.30	3.65 5.50
340	30	115	29.38	6.50	29.80 31.00	2.30 2.40	4.45 3.55	8.15 11.20
341	30	116	29.38	8.10	28.05 29.15	3.65 4.00	4.30 3.40	12.40 18.60
343	30	103	29.40	10.80	29.25 30.45	5.90 6.00	4.45 3.50	18.85 27.35
344	30	104	29.40	11.80	26.35 27.70	7.60 7.65	4.05 3.25	23.25 33.10
345	30	99	29.40	11.90	24.50 25.55	8.70 8.00	3.65 3.00	25.90 34.15

COANDA/JFD EJECTOR

TEST DATA

$s/a = 3.0,\ \sigma = 1.30$

ALL SLOTS SEALED

RUN	β	T_o °F	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R L	$P_{o2} - P_\infty$ " (2.95) R L	ΔP_1 " (H_2O) R L	ΔP_2 " (H_2O) R L
335	30	115	29.38	4.50	27.30 28.55	---- ----	4.15 3.30	---- ----
338	30	111	29.38	9.90	30.30 31.50	5.10 5.70	4.55 3.65	16.95 25.50
339	30	108	29.38	4.50	27.30 28.55	1.05 1.15	4.15 3.30	3.65 5.50
340	30	115	29.38	6.50	29.80 31.00	2.30 2.40	4.45 3.55	8.15 11.20
341	30	116	29.38	8.10	28.05 29.15	3.65 4.00	4.30 3.40	12.40 18.60
343	30	103	29.40	10.80	29.25 30.45	5.90 6.00	4.45 3.50	18.85 27.35
344	30	104	29.40	11.80	26.35 27.70	7.60 7.65	4.05 3.25	23.25 33.10
345	30	99	29.40	11.90	24.50 25.55	8.70 8.00	3.65 3.00	25.90 34.15

COANDA/JFD EJECTOR

TEST DATA

$s/a = 1.0$, $\sigma = 1.12$

ALL SLOTS SEALED

RUN	β	T_o ^oF	P_∞ " Hg	$P_\infty - P_{ch}$ " (H_2O)	$P_{o1} - P_\infty$ " (2.95) R / L	$P_{o2} - P_\infty$ " (2.95) R / L	ΔP_1 " (H_2O) R / L	ΔP_2 " (H_2O) R / L
360	20	125	29.55	9.10	35.70 37.55	2.25 2.40	5.40 4.25	1.60 1.70
361	20	127	29.55	9.70	32.25 35.05	4.15 4.40	5.10 4.00	2.55 2.60
362	20	127	29.55	10.20	31.50 33.15	6.40 6.50	4.85 3.90	3.40 3.40
363	20	123	29.55	10.30	30.05 31.70	8.40 8.70	4.65 3.65	4.15 4.20
364	20	121	29.55	10.50	28.75 30.05	10.60 10.80	4.45 3.55	4.85 5.00

APPENDIX III

PERFORMANCE DATA

The thrusts, mass flows and performance parameters, derived by the methods described in Appendix I, using the data presented in Appendix II, are presented in tabular form. The symbols and units used in this appendix are as follows.

F_{pri} - Primary jet thrust (lbs.)

F_{jfd} - Jet flap thrust (lbs.)

m_1 - Primary jet mass flow (slugs/sec.)

m_2 - Diffuser jet mass flow (slugs/sec.)

E - Diffuser jet power ratio $(E_2/(E_1 + E_2))$

R - Right side of ejector

L - Left side of ejector

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
206	5.66 6.09	2.81 2.64	23.61	.010 .010	.011 .011	.125	1.844	1.276	3.511
207	4.79 5.21	3.71 3.44	21.95	.009 .009	.013 .013	.206	1.895	1.252	3.485
208	6.76 7.04	1.48 1.06	21.95	.011 .011	.008 .007	.032	1.561	1.188	3.082
209	4.83 5.12	5.51 5.47	25.57	.009 .009	.016 .016	.340	1.970	1.254	3.392
210	5.39 5.65	3.23 2.95	21.82	.010 .010	.012 .012	.164	1.764	1.198	3.304
211	5.90 6.19	1.90 1.73	20.86	.010 .010	.009 .009	.071	1.647	1.193	3.205
212	6.07 5.52	1.94 1.76	20.35	.010 .009	.009 .009	.076	1.668	1.201	3.241

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
213	6.04 5.54	2.07 1.90	20.49	.010 .009	.009 .009	.072	1.690	1.204	3.283
214	7.08 6.47	3.64 3.32	30.65	.011 .010	.012 .012	.137	2.066	1.412	3.906
216	6.39 5.87	4.04 3.76	25.58	.011 .010	.013 .013	.160	1.888	1.256	3.526
217	7.11 6.49	3.91 3.59	28.94	.011 .010	.012 .012	.118	1.977	1.332	3.754
218	5.94 5.47	2.18 2.89	24.03	.010 .009	.011 .011	.120	1.949	1.321	3.703
219	6.51 6.00	2.78 2.49	25.06	.011 .010	.011 .010	.094	1.887	1.314	3.630
220	6.34 5.81	1.99 1.82	22.40	.011 .010	.009 .009	.063	1.773	1.275	3.457

RUN	F_{pri} R / L	F_{jfd} R / L	F_{tot}	m_1 R / L	m_2 R / L	E	ϕ_p	ϕ_m	$-\Omega$
221	6.34 5.80	1.86 2.04	22.19	.011 .010	.009 .009	.061	1.760	1.262	3.433
222	6.57 6.04	2.22 2.73	24.21	.011 .010	.010 .011	.077	1.828	1.281	3.545
223	7.06 6.44	3.36 3.76	28.00	.011 .010	.012 .013	.133	1.900	1.293	3.595
224	6.55 6.01	3.86 4.07	27.32	.011 .010	.012 .014	.168	1.944	1.297	3.623
225	6.21 5.77	4.25 4.60	27.41	.011 .010	.013 .014	.208	1.993	1.308	3.645
226	5.87 5.39	4.63 4.84	27.23	.010 .009	.014 .015	.242	2.038	1.322	3.667
227	5.05 4.65	5.15 5.88	27.60	.009 .009	.015 .016	.330	2.205	1.392	3.813

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	Ξ	ϕ_p	ϕ_m	Ω
228	6.69 6.11	1.35 1.76	21.66	.011 .010	.007 .009	.040	1.651	1.220	3.249
229	8.24 7.48	.04 .04	21.76	.012 .011	.0003 .0003	.0004	1.384	1.303	2.766
230	7.71 7.04	1.09 1.26	22.99	.012 .011	.006 .007	.019	1.542	1.189	3.059
239	7.18 6.68	.60 .80	19.52	.011 .010	.004 .006	.009	1.401	1.127	2.791
240	7.72 6.95	.04 .04	20.35	.012 .011	.0003 .0003	.004	1.373	1.292	2.746
241	6.94 6.38	1.46 1.54	21.75	.011 .010	.007 .008	.037	1.598	1.190	3.145
242	6.89 6.28	1.43 1.63	21.50	.011 .010	.007 .008	.038	1.595	1.184	3.139

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
2.43	7.02 6.43	1.97 2.33	23.35	.011 .010	.009 .010	.063	1.670	1.198	3.253
244	7.32 6.77	2.77 3.68	27.87	.011 .010	.011 .013	.106	1.849	1.276	3.540
245	6.77 6.18	3.91 4.23	27.22	.011 .010	.013 .014	.160	1.881	1.255	3.530
246	6.76 6.20	3.44 4.25	27.04	.011 .010	.012 .014	.156	1.882	1.264	3.523
305	6.08 5.58	4.53 5.47	27.41	.010 .009	.013 .016	.246	1.977	1.279	3.545
306	5.44 4.97	5.04 6.17	27.50	.010 .009	.014 .017	.314	2.090	1.325	3.623
247	6.60 5.95	3.77 4.56	27.86	.011 .010	.012 .014	.170	1.979	1.312	3.682

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
248	6.05 5.56	3.12 3.57	24.58	.010 .009	.011 .013	.144	1.924	1.295	3.624
249	6.55 6.03	2.60 3.03	24.46	.011 .010	.010 .011	.102	1.820	1.260	3.492
250	7.37 6.80	2.04 2.42	24.90	.011 .010	.009 .010	.058	1.696	1.219	3.311
251	6.16 5.66	1.32 1.70	19.68	.010 .009	.007 .008	.044	1.621	1.192	3.185
252	7.16 6.59	.728 1.000	20.12	.011 .010	.005 .006	.013	1.453	1.146	2.891
253	7.36 6.72	.041 .041	20.57	.011 .010	.0003 .0003	.0005	1.464	1.376	2.927
301	5.25 4.83	5.26 6.18	28.25	.010 .009	.014 .017	.330	2.184	1.378	3.755

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
302	6.31 5.80	4.16 4.69	27.99	.011 .010	.013 .015	.198	2.019	1.326	3.708
303	6.07 5.61	4.54 5.49	28.38	.010 .009	.013 .016	.241	2.048	1.324	2.685
254	6.85 6.28	.73 1.00	19.25	.011 .010	.005 .007	.015	1.453	1.141	2.889
255	6.50 6.29	1.44 1.73	21.81	.011 .010	.007 .009	.045	1.660	1.225	3.258
256	6.96 6.38	1.99 2.36	23.85	.011 .010	.009 .010	.064	1.718	1.230	3.347
257	6.14 5.63	2.64 3.15	23.31	.010 .009	.010 .012	.114	1.840	1.262	3.510
258	7.01 6.49	3.17 3.91	27.64	.011 .010	.011 .013	.127	1.885	1.282	3.573

RUN	F_{pri} R / L	F_{jfd} R / L	F_{tot}	m_1 R / L	m_2 R / L	E	$\emptyset_p$	$\emptyset_m$	Ω
259	6.41 5.90	3.66 4.43	26.74	.011 .010	.012 .014	.175	1.930	1.282	3.584
260	6.50 5.97	3.79 4.67	26.80	.011 .010	.012 .015	.182	1.899	1.257	3.515
261	6.07 5.52	3.21 3.71	23.83	.010 .009	.011 .013	.152	1.859	1.246	3.487
262	6.64 6.11	2.64 3.20	24.18	.011 .010	.010 .012	.103	1.775	1.224	3.402
263	6.25 5.75	1.97 2.40	21.88	.011 .010	.009 .010	.076	1.739	1.230	3.373
264	7.07 6.53	1.43 1.83	22.46	.011 .010	.007 .009	.038	1.615	1.195	3.181
265	6.11 5.70	.74 .94	17.62	.010 .009	.005 .006	.016	1.478	1.152	2.937

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
266	6.31 5.77	4.23 5.12	27.74	.011 .010	.013 .015	.217	1.775	1.241	3.597
268	5.77 5.34	4.66 5.47	27.64	.010 .009	.013 .016	.267	2.053	1.322	3.647
269	5.36 4.96	5.11 5.97	27.26	.010 .009	.014 .016	.324	2.070	1.316	3.568
270	5.36 4.97	5.10 5.95	26.78	.010 .009	.014 .017	.348	1.984	1.270	3.381
271	5.73 5.30	4.84 5.66	26.92	.010 .009	.014 .016	.303	1.951	1.258	3.402
272	6.24 5.74	4.40 5.18	26.97	.011 .010	.013 .015	.246	1.891	1.237	3.393
273	6.00 5.54	4.37 5.11	26.54	.010 .009	.013 .015	.255	1.918	1.252	3.425

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
274	6.50 5.93	3.94 4.67	26.66	.011 .010	.012 .014	.205	1.864	1.235	3.410
275	6.92 6.36	3.48 4.31	27.08	.011 .010	.012 .014	.163	1.829	1.232	3.412
276	6.31 5.83	2.94 3.50	24.10	.011 .010	.011 .012	.140	1.811	1.232	3.415
277	6.80 6.27	2.47 2.99	24.53	.011 .010	.010 .011	.097	1.764	1.231	3.389
278	6.38 5.84	1.91 2.32	21.88	.011 .010	.008 .010	.070	1.713	1.219	3.328
279	6.23 5.94	1.33 1.76	19.53	.010 .009	.007 .009	.044	1.589	1.167	3.122
280	5.94 5.49	.79 1.11	17.21	.010 .009	.005 .007	.020	1.489	1.143	2.953

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	$\emptyset_p$	$\emptyset_m$	Ω
329	6.14 5.48	2.02 2.20	21.57	.010 .009	.009 .010	.073	1.768	1.252	3.443
330	5.76 5.19	3.16 4.07	24.78	.010 .009	.011 .014	.175	1.994	1.327	3.734
331	5.60 5.02	4.43 5.21	26.56	.010 .009	.014 .016	.261	2.049	1.323	3.699
335	6.01 5.49	.15 .15	20.60	.010 .009	.001 .001	.002	1.789	1.583	3.574
338	6.66 6.09	3.56 4.53	28.16	.011 .010	.012 .014	.137	2.018	1.338	3.812
339	6.01 5.49	.90 1.13	20.94	.010 .009	.005 .007	.012	1.807	1.377	3.594
340	6.52 5.95	1.79 2.12	21.50	.011 1010	.008 .009	.041	1.682	1.205	3.306

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
329	6.14 5.48	2.02 2.20	21.57	.010 .009	.009 .010	.073	1.768	1.252	3.443
330	5.76 5.19	3.16 4.07	24.78	.010 .009	.011 .014	.175	1.994	1.327	3.734
331	5.60 5.02	4.43 5.21	26.56	.010 .009	.014 .016	.261	2.049	1.323	3.699
335	6.01 5.49	.15 .15	20.60	.010 .009	.001 .001	.002	1.789	1.583	3.574
338	6.66 6.09	3.56 4.53	28.16	.011 .010	.012 .014	.137	2.018	1.338	3.812
339	6.01 5.49	.90 1.13	20.94	.010 .009	.005 .007	.012	1.807	1.377	3.594
340	6.52 5.95	1.79 2.12	21.50	.011 1010	.008 .009	.041	1.682	1.205	3.306

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
341	6.21 5.64	2.64 3.32	24.04	.010 .009	.010 .012	.094	1.911	1.300	3.677
343	6.46 5.85	4.00 4.85	28.89	.011 .010	.012 .015	.161	2.107	1.377	3.937
344	5.83 5.36	4.91 5.88	28.39	.010 .009	.014 .017	.244	2.131	1.355	3.834
345	5.33 4.94	5.45 6.07	27.98	.010 .009	.015 .017	.294	2.189	1.373	3.846
360	7.91 7.21	9.67 1.01	23.61	.012 .011	.004 .004	.021	1.541	1.325	3.055
361	7.28 6.75	1.45 1.48	24.14	.011 .010	.004 .004	.054	1.164	1.390	3.255
362	7.01 6.46	1.93 1.94	23.50	.011 .010	.005 .005	.096	1.639	1.343	3.152

RUN	F_{pri} R L	F_{jfd} R L	F_{tot}	m_1 R L	m_2 R L	E	ϕ_p	ϕ_m	Ω
363	6.70 6.11	2.35 2.39	23.55	.011 .010	.006 .006	.144	1.670	1.349	3.150
364	6.40 5.85	2.78 2.84	24.30	.011 .010	.006 .006	.196	1.730	1.382	3.188

REFERENCES

1. Alperin, Morton; Harris, Gordon; and Smith, Charles "An Experimental Investigation of New Concepts in Ejector Thrust Augmentation for V/STOL" Technical Report AFFDL-TR-69-52, June 1969 (Flight Dynamics Research Corporation)

2. Alperin, Morton; Marlotte, Gary "A Jet Flap Diffuser Ejector" Technical Report AFFDL-TR-71-66, June 1971 (Flight Dynamics Research Corporation)

3. Fancher, Richard B. Capt. "A Compact Thrust Augmentation Ejector Experiment" Technical Report ARL 70-0137, August 1970 (Energetics Research Laboratory, Aerospace Research Laboratory, AFSC)

4. Drummond, A.N.: and Gould, D.G. "Experimental Thrust Augmentation of a Variable Geometry, Two-Dimensional Central Nozzle Ejector" Aeronautical Report LR-328, January 1962 (National Research Council of Canada)

5. Scott, W.J. "Experimental Thrust Augmentation of a Variable Geometry, Two-Dimensional, Coanda Wall Jet Ejector" Aeronautical Report LR-34, January 1964 (National Research Council of Canada)

6. Morel, Jean-Pierre "Theoretical Solutions for the Jet Flap Diffuser" Thesis, California Institute of Technology, May 1969.

7. Morel, Jean-Pierre and Lissaman, Peter B.S. "The Jet Flap Diffuser: A New Thrust Augmenting Device" A/AA Paper No. 69-777 July 1969, California Institute of Technology.